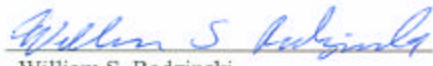





CRITERION 401

FREEZE PROTECTION

SIGNATURES

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RECORD OF REVISIONS

Revision No.	Date	Description
0	08/27/98	Initial Issue. Replaces 3.7-600, Rev. 0. Deleted Forward, Statement of Authority, Maintenance Standard Update, 1.0 General Requirements, and 2.0 LANL Maintenance Policy Documents.
1	01/08/02	This revision includes the addition of a Table of Contents, the use of Basis Statements in Sections 6 and 7 further clarification based on the new Criterion Writer's Guide, incorporates a review of ORPS & NRC lessons learned 1/1/95 to 6/2000, and reinstates requirements based on Type B Accident Investigation Board Report, Chiller Line rupture at Technical Area 35, Building 27. This revision also incorporates the comments and rewording requested by the FMC Maintenance Subcommittee.
	02/26/02	Incorporation of comment and rewording requested by the Maintenance Subcommittee.
	5/15/02	Incorporation of comments from review by Maintenance Subcommittee.
	7/25/02	Incorporation of comments Section 6.2.1 from FM Council
2	01/14/05	Incorporate DOE definition of freezing conditions. Update DOE references

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CRITERION 401**FREEZE PROTECTION****1.0 PURPOSE**

The purpose of this Criterion is to ensure a program is in place to prevent damage to buildings and equipment during cold weather. This document addresses the requirements of LIR 230-05-01 (Ref. 10.1), "Operations and Maintenance Manual."

Implementation of this Criterion satisfies DOE O 433.1 (Ref 10.2) for the subject equipment / system. Compliance with DOE O 433.1A is required by Appendix G of the UC Contract.

2.0 SCOPE

Numerous incidents and several occurrences have been recorded involving the failure of, or the lack of a freeze protection program. The reports from each of these occurrences established corrective actions requiring LANL to develop and implement an institutional freeze protection program. This criterion is established as an institutional requirement to satisfy those corrective actions.

This document requires each Facility Management Unit to establish a freeze protection plan for each applicable facility. The requirements stated below are based on the DOE Maintenance Management program guidelines (DOE O 433.1 and DOE G 433.1-1, which are mandatory for nuclear facilities) (Ref. 10.3), but shall be applied to all LANL facilities in a graded approach.

This Criterion does not address corrective maintenance actions required to repair or replace equipment or failures due to conditions beyond design limitations of the subject system.

3.0 ACRONYMS AND DEFINITIONS**3.1 Acronyms**

AR	Administrative Requirements
CFR	Code of Federal Regulations
CRE	Condenser, Refrigeration, Evaporative
CWE	Cooler, Water, Evaporation
KSL	KBR SHAW LATA
LIR	Laboratory Implementing Requirement
LIG	Laboratory Implementing Guidance
LPR	Laboratory Performance Requirement

ML	Management Level
NFPA	National Fire Protection Agency
O&M	Operations and Maintenance
PMI	Preventive Maintenance Instruction
PPE	Personal Protection Equipment
PP&PE	Personal Property and Programmatic Equipment
RP&IE	Real Property and Installed Equipment
SSC	Structures, Systems, and Components
SSS	Support Services Subcontractor for LANL
UC	University of California

3.2 Definitions

Drip Leg. A section of pipe which gathers steam-condensate, dirt, and corrosion products in a steam line and allows the solids to separate to the bottom of the drip leg so they will not clog the strainers and steam traps.

Cold Weather Conditions. Temperatures less than or equal to 35⁰F. Routine freeze protection surveillance commence when these conditions occur.

Freeze Stat. Temperature sensing device placed near coil or heating surface to close dampers and/or shut off supply fan and fail unit to full heat.

Structure, System, and Component (SSC). Structure is an element or a collection of elements that provides support or enclosure such as a building, freestanding tank, basin, dike, or stack. System is a collection of components assembled to perform a function such as piping, cable trays, conduits, or heating, ventilation, and air conditioning. Component is an item of equipment such as a pump, valve, or relay, or an element of a larger array such as a length of pipe, elbow, or reducer.

Steam Trap. A device which passes condensate and stops steam from passing into the condensate return system.

Vacuum Breaker. A device which prevents condensing steam from creating a vacuum, allows the condensate to drain from the heating coil by gravity, and therefore prevents the condensate from freezing in a system which is correctly configured.

4.0 RESPONSIBILITIES

4.1 FM – Maintenance and System Engineering (MSE)

- 4.1.1** FM-MSE is responsible for the technical content of this Criterion and monitoring the applicability and the implementation status of this Criteria and either assisting the organizations that are not applying or meeting the implementation expectations contained herein or elevating their concerns to the director(s).

Basis: LIR 301-00-01.11; Issuing and Managing Laboratory Operations Implementation Requirements and Guidance, Section 5.4, OIC Implementation Requirements

- 4.1.2** FM-MSE shall provide technical assistance to support implementation of this Criterion.

4.2 Facility Manager

- 4.2.1** Responsible for operations and maintenance of institutional, or Real Property and Installed Equipment (RP&IE) under their jurisdiction, in accordance with the requirements of this document.

- 4.2.2** Responsible for operations and maintenance of those Personal Property and Programmatic Equipment (PP&PE) systems and equipment addressed by this document that may be assigned to the FM in accordance with the FMU-specific Facility/Tenant Agreement.

4.3 Group Leader

- 4.3.1** Responsible for implementing operational and maintenance surveillance programs including the preparation and maintenance of required procedures and documentation for PP&PE under their jurisdiction that is covered by this Criterion.

4.4 Authority Having Jurisdiction (AHJ) – POC for Mechanical Chapter of LANL Engineering Manual

- 4.4.1** Responsible for providing a decision on a specific technical question regarding national, state and local codes, standards and DOE Orders.

5.0 PRECAUTIONS AND LIMITATIONS

5.1 Precautions

This section is not intended to identify all applicable precautions necessary for implementation of this Criterion. A compilation of all applicable precautions shall be contained in the

implementing procedure(s) or work control authorization documents. The following precautions are intended only to assist the author of a procedure or work control document in the identification of hazards/precautions that may not be immediately obvious.

5.2 Limitations

The intent of this Criterion is to identify the minimum generic requirements and recommendations for SSC operation and maintenance across the Laboratory. Each user is responsible for the identification and implementation of additional facility specific requirements and recommendations based on their authorization basis and unique equipment and conditions, (e.g., equipment history, manufacturer warranties, operating environment, vendor O&M requirements and guidance, etc.). Nuclear facilities and moderate to high hazard non-nuclear facilities will typically have additional facility-specific requirements beyond those presented in this Criterion.

Nuclear facilities shall implement the requirements of DOE O 433.1 (Ref. 10.3) as the minimum programmatic requirements for a maintenance program. Additional requirements and recommendations for SSC operation and maintenance may be necessary to fully comply with the current DOE Order or CFR identified above.

6.0 REQUIREMENTS

Minimum requirements that Criterion users shall follow are specified in this section. Requested variances to these requirements shall be prepared and submitted to FM-MSE in accordance with LIR 301-00-02 (Ref. 10.6), "Variances and Exceptions to Laboratory Operations Requirements," for review and approval. The Criterion users are responsible for analysis of operational performance and SSC replacement or refurbishment based on this analysis. Laws, codes, contractual requirements, engineering judgement, safety matters, and operations and maintenance experience drive the requirements contained in this section.

6.1 Operations Requirements

No requirements beyond those stated in Section 5.2, Limitations.

6.1.1 Pre-Operational Inspections

6.1.2 No pre-operational inspections identified.

6.2 Maintenance Requirements

6.2.1 A freeze protection plan shall be prepared for each facility utilizing a graded approach. The plan will detail the actions and requirements to be imposed on the facility to ensure protection of the equipment/facility from cold weather or freezing. The plan will ensure that, in all cases, the actions and requirements imposed to provide cold weather/freezing protection comply with the facility configuration management procedures and are reviewed by facility operations and safety personnel to assure that the facility will be maintained in a safe condition to protect the health and safety of the public. For purposes of the freeze protection plan, “facility” may be defined as a group of buildings and related infrastructure.

6.2.2 The freeze protection plan shall include details on inspections, preventive maintenance, and corrective maintenance imposed to ensure continued safe facility operations. Inspections and self-assessments of freeze protection programs shall be appropriately scheduled to assure correction of deficiencies and preparation of other compensatory measures to protect the facilities prior to the beginning of cold weather conditions. As a minimum, address the following during plan preparation:

- A. Heating systems will be cleaned, serviced, and functionally tested.
- B. Antifreeze used in cooling systems will be checked and replaced as necessary.
- C. Heating system power and temperature controls will be protected against inadvertent deactivation.
- D. All air intakes, windows, doors, and others access ways that could provide abnormal inflows of cold air shall be secured. Automatically controlled systems of this type will be functionally tested.
- E. When temperatures fall below design conditions (5°F at Los Alamos), the need for increased surveillance is addressed.

Note: See page 52 of Los Alamos Climatology, LA-11735-MS for additional Low Temperature Design Conditions. (Ref. 10.26)

- F. Facility personnel will inspect, test, and stage portable auxiliary heaters and have identified sources to obtain more, if needed.
- G. The main water supply cutoffs for each facility will be identified, tested, and readily accessible to emergency personnel responding to a freeze/thaw incident.
- H. Outside storage pads and unheated storage areas will be inspected to ensure that there are no materials susceptible to freeze damage.
- I. Employees will be aware of the need to identify and report any suspected problem with heating or other cold weather protection equipment.

- J. Provisions are made to remove temporary cold weather protection features after the cold weather season or freezing period is over.
- K. Wet-pipe sprinkler systems will be reviewed for areas susceptible to freezing, and appropriate actions planned, such as provisions for auxiliary heat; draining and posting a fire watch/etc.
- L. For steam systems: blow down drip legs, clean strainers, test freeze stat actuation of control valves and dampers, check steam traps, control actuators/valves, face and bypass dampers, linkages, and temperature controllers. Ensure that a vacuum breaker is installed and in working order on all preheat and heating coils which may be exposed to freezing conditions.
- M. For ventilation systems: test and calibrate all freeze stats, and check operation of valves, dampers, linkages, control actuators, and temperature controllers.
- N. Drain and remove water from all seasonal cooling systems (unless protected by antifreeze or heat tape) and yard watering systems. Leave all vents and drain valves open.
- O. Inspect conditions of all heat tapes, basin heaters and contact heaters. Verify operations and temperature settings and test ground-fault equipment protection.

Note: Ground Fault Equipment protection must be installed per NEC 427-22. (Ref. 10.24)

Basis: Type B Accident Investigation Board Report Chiller Line Rupture at Technical Area 35, Building 27 Los Alamos National Laboratory:

INTERPRETATION OF SIGNIFICANCE

The large property loss of \$3.2 million at Los Alamos National Laboratory on November 17, 1997, was a result of failure by the University of California to protect the Department of Energy's assets. A chiller line ruptured because of freezing temperatures, and the water collected in the sub-basement of a building because of the failure of the sump system. As a result of the flooding there was a total loss of the contents in the sub-basement and damage to the building. Inadequacies in the Laboratory's maintenance program and lessons learned program contributed heavily to this incident.

Although the facilities and equipment were considered by line management to be old and deteriorating, adequate assessments were not made to determine the consequences to missions should equipment fail. Even though there were institutional maintenance standards, they were guidance and were not required to be implemented by line management. As a result, a freeze protection plan was not implemented. A complete approach to maintenance by the Laboratory

is needed that emphasizes implementation of requirements and procedures, individual and line responsibility and accountability, effective training, and through oversight and feedback to management.

To prevent recurrence, line management must learn from previous incidents. Although information concerning other freeze protection incidents was known by the laboratory, they did not ensure that the applicable lessons were implemented institutionally.

CASUAL FACTORS

The direct cause of the incident was the improper setting of the reservoir setpoint temperature, which caused the dampers to remain open during subfreezing temperatures.

The root causes were: (1) failure by LANL to implement an effective institutional lessons learned program, (2) failure by LANL to ensure the facility management organization was knowledgeable of the operations of the mechanical systems, (3) failure by LANL to ensure the roles and responsibilities of the facility management organizations were clear and understood, (4) failure by LANL to establish maintenance requirements, and (5) failure by LANL, to provide oversight of facility management maintenance activities.

The contributing causes were: (1) maintenance categorization of equipment was incorrect, (2) maintenance was not conducted more frequently based on established criteria, (3) legacy design features were not reevaluated after the facilities and mission changed, (4) failure by DOE/AL and LAAO to provide oversight of the FM maintenance activities, and (5) radiological source control was not completely developed and implemented.

Required items for freeze plan from Freeze Plan from DOE G 433.1-1, 4.18.3.2 Cold Weather Preparation.

7.0 RECOMMENDED AND GOOD PRACTICES

The information provided in this section is recommended based on acceptable industry practices and should be implemented by each user based on his/her unique application and operating history of the subject systems/equipment.

7.1 Operations Recommendations

- 7.1.1** The average number of days in which the temperature drops below freezing in Los Alamos is 208 days. Anticipating freeze conditions and protecting buildings, equipment and grounds against freeze damage is a vital part of a Facility Maintenance Program. Good

practices in freeze protection are:

- Develop a checklist for each applicable facility, complete with signature blocks for the responsible person performing the inspection and for the responsible manager to review and ensure that deficiencies have been corrected.
- Perform a root cause investigation of all freeze damage incidents, utilize the results to improve the freeze protection plans program, and forward the results to the institutional lessons learned program.
- The plans should target full utilization of engineering controls such as; equipment surveillance system alarms, antifreeze, heat tracing, vacuum breakers, freeze stats and fluid temperature sensing valves.
- Perform an annual review of the facilities to document facility additions and modifications, and add appropriate measures in the freeze protection plans to protect the new equipment or structures.
- Steam systems are more complex than hydronic systems and must be designed, installed, and maintained correctly to prevent freezing occurrences. Consider having a competent steam system specialist evaluate the systems periodically and ensure that recommended modifications are installed correctly, that procedural changes are implemented, and that the maintenance staff is properly trained.
- Provided it has been reviewed and approved by FM-MSE, SSS craftsman should comply with PMI 40-35-016, Anti-Freeze System Inspection and Testing. (Ref. 10.7)

Basis: Anticipating Freeze conditions and protecting buildings, equipment, and grounds is a vital part of a Facility Maintenance Program.

7.1.2 Cold Weather Programs for Fire Protection Systems

7.1.2.1 Provide the Following inspections to Fire Protection Systems.

- Maintain extra building heat during periods of extreme cold, especially during idle periods, to keep sprinkler piping from freezing. Check the heating system to ensure that it is delivering sufficient heat to all areas, particularly at night.
- Search for isolated drafts or air leaks, particularly in infrequently visited areas and in spaces where sprinkler pipes are installed. Look specifically for places where cold air could enter and eliminate even small openings. Keep all doors, especially large shipping doors, tightly closed.
- After a prolonged period of abnormally cold weather, make drain tests of sprinkler risers wherever possible to determine if underground mains are frozen. Open the drain wide, let it run for 30 seconds or more, then shut it off. If the pressure fails to return to normal promptly clear the mains of ice as soon as possible.

Basis: DOE/EH-0213 “Cold Weather Protection,” October 1991, Office of Environment, Safety and Health, Bulletin 91-4 (Reference 10.9)

7.1.3 Cold Weather Programs Related to Hazardous Materials

7.1.3.1 Perform the following inspections for Hazardous Materials.

- Ensure that all containers used for hazardous or toxic materials are properly stored, and inspect them for deterioration prior to handling. If containers become brittle (due to combination of chemical attack, freezing temperatures, and ultraviolet light), they may break when moved.
- Liquids should not be permitted to remain in unheated process lines during periods when production has been stopped. All lines should be drained and purged to prevent future line breakage due to freezing temperatures.
- Ensure that piping and valves (particularly check valves and dump valves) in systems that carry hazardous or toxic substances are properly insulated. Install insulators such as heat blankets, heat tape, or frost boxes, as appropriate.
- Inspect all anti-freeze loop valves to ensure that they are in the open position. Chain and lock them in the open position if possible.

Basis: DOE/EH-0213 “Cold Weather Protection,” October 1991, Office of Environment, Safety and Health, Bulletin 91-4. (Ref. 10.9)

7.2 Maintenance Recommendations

7.2.1 General Guidelines

7.2.1.1 During Extreme Temperature Excursions provide a walk down of inside heated buildings on components located in out of the way areas like closets, stairwells, attics, and vestibules, or located very close to exterior walls and determine the temperature using a laser aimed temperature measuring device for equipment and materials.

Basis: Extended periods of severe cold weather temperatures can exceed capabilities of normal Cold Weather Protection Programs. Lessons Learned Database, “Freeze Protection During Extreme Weather Excursions,” Identifier: 1996-RL-WHC-0026 (Ref. 10.10)

7.2.1.2 When performing work in the vicinity of heat tracing tape, one should look for damaged insulation on all exposed portions of the cord. If possible, check both ends of the cord for loose connections. Ensure the heat tracing is protected by a Ground Fault Equipment Protector (GFEP).

Basis: An exposed conductor may come in contact with maintenance personnel during maintenance activities resulting in sparks or injury. Lessons Learned Database,

“Personnel Contact with Energized Heat Tracing,” Identifier: Y-1996-OR-LIMESPAN-0101 (Ref. 10.11)

- 7.2.1.3 Verify that deficiencies identified during the previous cold weather season have been corrected and that modifications to correct or enhance freeze protection capabilities are appropriately prioritized and scheduled before the beginning of the cold weather season.

Basis: Lessons Learned Database, Operating Experience Weekly Summary 98-34, “Freeze Protection Reminder.” (Ref. 10.12) Lessons Learned Database, Operating Experience Weekly Summary 2000-03, “Freeze Protection Problems Cause Damage and Loss of Fire Protection.” (Ref. 10.19)

- 7.2.1.4 Inspect, remove debris, and patch/repair (if needed): roof drains, scuppers, canales, gutters, and down spouts before the first frost. Also, remove from roofs any items that could impede the normal flow of water or ice.

Basis: DOE G 433.1-1 4.98.3.2 Cold Weather Preparations. (Ref. 10.25)

- 7.2.1.5 Provide Guidance for planning and decommissioning activities to manage the risks posed by the facility from freeze damage in partially unoccupied or unoccupied buildings by the following measures:

- Conducting weekly walk downs in unoccupied parts of the building
- Conducting daily walk downs during frigid temperatures

Basis: Lessons Learned Database, Operating Experience Weekly Summary 95-50, “Fire Protection Sprinkler Line Freeze.” (Ref. 10.17) DOE/EM-014P, “Decommissioning Handbook.” (Ref. 10.18, Section 3.1.2)

8.0 GUIDANCE

8.1 Operations Guidance

- 8.1.1 No operations guidance available

8.2 Maintenance Guidance

8.2.1 Anti-Freeze Sprinkler System Inspection and Testing

- 8.2.1.1 Provided it has been reviewed by FM-MSE, an acceptable maintenance program that covers those fire suppression systems which are protected with anti-freeze similar to KSL PMI 40-35-017, “Anti-freeze Sprinkler System Inspection and Testing,” (Ref. 10.7) may be used.

8.2.2 Dry Sprinkler System Inspection and Testing

- 8.2.2.1 Provided it has been reviewed by FM-MSE, an acceptable program that covers dry sprinkler systems similar to KSL PMI 40-35-062, Rev. 1, "Dry Sprinkler System Inspection and Testing," (Ref. 10.20) may be used. This only covers draining low points after testing, but does not address freeze protection of flooded parts of the system.

8.2.3 Water Treatment Program

- 8.2.3.1 Provided it as been reviewed by FM-MSE, an acceptable program that covers the freeze protection of CWE and CRE similar to KSL PMI 40-40-004, Rev. 4, "Cooling Unit Maintenance & Water Treatment Manual," (Ref. 10.21) may be used. Freeze protection for air wash systems and cooling towers is not addressed in this document.

8.2.4 Steam Traps

- 8.2.4.1 Provided it has been reviewed by FM-MSE, an acceptable program that tests steam traps similar to KSL PMI 40-40-009, "Steam Trap Preventive Maintenance and Repair," (Ref. 10.22) may be used. This only covers steam traps but does not check vacuum breakers or ensure that strainers are clean.

9.0 REQUIRED DOCUMENTATION**9.1 Freeze Protection Plan**

Basis: See Section 6.2.2

10.0 REFERENCES

- 10.1** LIR 230-05-01.0, *Operations and Maintenance Manual*.
- 10.2** DOE Order 430.1A, *Life Cycle Asset Management Order*. Attachment 2: "Contractors Requirements Document," Page 14, 10-14-98.
- 10.3** DOE O 433.1, *Maintenance Management Program*
- 10.4** DOE Order 225.1A, Accident Investigation.
- 10.5** Type B Accident Investigation Board Report, Chiller Line rupture at TA-35, Building 27, Los Alamos National Laboratory, Final Report dated February 1998.
- 10.6** LIR 301-00-02.0, *Variances and Exceptions to Laboratory Operations Requirements*.
- 10.7** KSL PMI 40-35-017, *Anti-Freeze System Inspection and Testing*.

- 10.8** DOE-STD-1064-94, Guideline to Good Practices for Seasonal Facility Preservation at DOE Nuclear Facilities.
- 10.9** DOE/EH-0213 “*Cold Weather Protection*,” October 1991, Office of Environment, Safety and Health, Bulletin 91-4
- 10.10** Lessons Learned I.D. 1996-RL-WHC-0026: *Freeze Protection During Extreme Weather Excursions*.
- 10.11** Lessons Learned I.D. Y-1996-OR-LIMESPAN-0101: *Personnel Contact with Energized Heat Tracing*.
- 10.12** Lessons Learned Operating Experience Weekly Summary 98-34: *Freeze Protection Reminder*.
- 10.13** Lessons Learned Operating Experience Weekly Summary 99-16: *Lessons Not Learned From Previous Events Result In Freeze Damage To Fire Suppression Line*.
- 10.14** NFPA Fire Protection Code.
- 10.15** Lessons Learned Operating Experience Weekly Summary 96-52: *Emergency Declared When Fire System Pipe Breaks*.
- 10.16** Lessons Learned Operating Experience Weekly Summary 96-06: *Freeze Damage Across The DOE Complex*.
- 10.17** Lessons Learned Operating Experience Weekly Summary 95-50: *Fire Protection Sprinkler Line Freeze*.
- 10.18** DOE/EM-014P, *Decommissioning Handbook*.
- 10.19** Lessons Learned Operating Experience Weekly Summary 2000-03: *Freeze Protection Problems Cause Damage And Loss Of Fire Protection*.
- 10.20** KSL, PMI Number 40-35-062, Rev. 1, *Dry Sprinkler System Inspection and Testing*.
- 10.21** KSL, PMI Number 44-40-004, Rev. 4, *Cooling Unit Maintenance & Water Treatment Manual*.
- 10.22** KSL, PMI Number 40-40-009, *Steam Trap Preventive Maintenance and Repair*.
- 10.23** LPR 230-07-00.0, *Maintenance History*, Performance Criteria 2.
- 10.24** National Electrical Code, Article 427, Section 22 *Equipment Protection*.
- 10.25** DOE G 433.1-1 4.18.3.2, *Cold Weather Preparations*.
- 10.26** Los Alamos Climatology, LA-11735-MS, page 52

11.0 APPENDICES

None.